

**CLAIMS**

- 1 1. A method of treating a waste stream, the method comprising the steps of:
- 2 a. conducting at least a portion of the waste stream to a treatment vessel for
- 3 treatment comprising contact with a first biological population having a first-
- 4 biological population profile;
- 5 b. drawing off a portion of the waste stream;
- 6 c. controlling the drawn-off portion of the waste stream so as to maintain, in the
- 7 drawn-off portion, a second biological population having a second-biological
- 8 population profile different from the first-biological population profile; and
- 9 d. returning a fraction of the drawn-off portion to the treatment vessel following
- 10 contact with the second biological population, the returned fraction including a
- 11 portion of the second biological population.
- 

- 12
- 1 2. The method of claim 1 wherein the second biological population exhibits a lower solids
- 2 yield and a higher waste-digestion efficiency relative to the first biological population.
- 3

- 1 3. The method of claim 1 wherein the second biological population includes a higher
- 2 proportion of facultative aerobes than the first biological population .
- 3

- 1 4. The method of claim 1 wherein the second biological population includes a higher
- 2 proportion of facultative anaerobes than the first biological population.
- 3

1 5. The method of claim 1 wherein the second biological population includes a higher  
2 proportion of nitrifiers than the first biological population.  
3

1 6. The method of claim 1 wherein the second biological population includes a lower  
2 proportion of filamentous biology than the first biological population.  
3

1 7. The method of claim 1 wherein the second biological population inhibits the formation of  
2 filamentous biology more than the first biological population.  
3

1 8. The method of claim 1 wherein the returned fraction contains a higher level of biological  
2 nutrients than the waste stream.  
3

---

1 9. The method of claim 1 wherein the returned fraction contains a higher level of cBOD  
2 than the waste stream.  
3

1 10. The method of claim 1 wherein the returned fraction contains a higher level of nitrates  
2 than the waste stream.  
3

1 11. The method of claim 1 wherein control of the drawn-off portion is effected through  
2 maintenance of a target ORP range.  
3

1 12. The method of claim 1 wherein control of the drawn-off portion is effected through  
2 maintenance of a target specific oxygen uptake rate range.

1 13. The method of claim 1 wherein control of the drawn-off portion is effected through  
2 maintenance of a target specific nitrate uptake rate range.  
3

1 14. The method of claim 1 wherein the controlling step comprises:

- 2 a. adding, to the drawn-off portion, a quantity of activated sludge to achieve a target  
3 suspended solids concentration;
- 4 b. mixing the drawn-off portion without aeration to achieve anaerobic conditions  
5 without substantial sulfide generation;
- 6 c. allowing settling to produce a decantable volume having a high cBOD and  
7 ammonia content and a low ORP,

8 the fraction of the drawn-off portion conducted to the treatment vessel being taken from the  
9 decantable volume.

---

10  
1 15. The method of claim 14 wherein the drawn-off portion is contained in an offline vessel,  
2 the undecanted drawn-off portion being conditioned for re-use by steps comprising:

- 3 a. adding a portion of the waste stream material to the offline vessel to produce  
4 therein a mixture having a second target suspended solids concentration; and
- 5 b. removing about half of the mixture.  
6

1 16. The method of claim 15 wherein the second target suspended solids concentration ranges  
2 from 7,500 mg/l to 10,000 mg/l.  
3

1 17. The method of claim 14 wherein the target suspended solids concentration ranges from  
2 3000 to 5000 mg/l.  
3

1 18. The method of claim 14 wherein the decantable volume is at least 25%.  
2

1 19. The method of claim 1 wherein the controlling step comprises:

- 2 a. adding, to the drawn-off portion, a quantity of activated sludge to achieve a target  
3 suspended solids concentration;
  - 4 b. mixing the drawn-off portion without aeration to achieve anaerobic conditions  
5 without substantial sulfide generation;
  - 6 c. mixing and aerating until a positive ORP is achieved;
  - 7 d. mixing without aeration to achieve anaerobic conditions; and
- 
- 8 e. allowing settling to produce a high-load decantable volume,

9 the fraction of the drawn-off portion conducted to the treatment vessel being taken from the  
10 decantable volume.  
11

1 20. The method of claim 19 wherein the undecanted drawn-off portion is re-used by steps  
2 comprising:

- 3 f. replacing the drawn-off fraction with activated sludge, and adding sufficient  
4 waste stream material to achieve a second target suspended solids concentration;  
5 and
- 6 g. repeating steps (b) through (e).

1 21. The method of claim 20 wherein the second target suspended solids concentration is not  
2 more than about 7,500 mg/l.

1 22. The method of claim 20 wherein after about two repetitions of steps (f) and (g) the  
2 undecanted drawn-off portion is treated according to steps comprising:

- 3 h. removing about 1/3 of the undecanted drawn-off portion; and  
4 i. repeating steps (a) through (h).

1 23. The method of claim 19 wherein the target suspended solids concentration ranges from  
2 about 5,000 mg/l to about 7,500 mg/l.

1 24. The method of claim 1 wherein the controlling step comprises:

- 
- 2 a. adding, to the drawn-off portion, a quantity of activated sludge to achieve a target  
3 suspended solids concentration;  
4 b. mixing the drawn-off portion without aeration to achieve anaerobic conditions  
5 without substantial sulfide generation;  
6 c. mixing and aerating until a positive ORP is achieved;  
7 d. mixing without aeration to achieve anaerobic conditions;  
8 e. allowing settling to produce a decantable volume;  
9 f. mixing and aerating until a positive ORP is achieved; and  
10 g. allowing settling to produce a low-load decantable volume,

11 the fraction of the drawn-off portion conducted to the treatment vessel being taken from the  
12 decantable volume.

1 25. The method of claim 24 wherein the undecanted drawn-off portion is re-used by steps  
2 comprising:

- 3 h. replacing the drawn-off fraction with activated sludge, and adding sufficient  
4 waste stream material to achieve a second target suspended solids concentration;  
5 and  
6 i. repeating steps (b) through (g).

1 26. The method of claim 25 wherein the second target suspended solids concentration is not  
2 more than about 7,500 mg/l.  
3

1 27. The method of claim 25 wherein after about two repetitions of steps (h) and (i) the  
2 undecanted drawn-off portion is treated according to steps comprising:

- 
- 3 j. removing about 1/3 of the undecanted drawn-off portion; and  
4 k. repeating steps (a) through (j).  
5

1 28. The method of claim 24 wherein the target suspended solids concentration ranges from  
2 about 5,000 mg/l to about 7,500 mg/l.  
3

1 29. The method of claim 1 wherein the controlling step comprises:

- 2 a. adding, to the drawn-off portion, a quantity of activated sludge to achieve a target  
3 suspended solids concentration;  
4 b. mixing the drawn-off portion with aeration to achieve aerobic conditions and low  
5 ammonia content;

- c. stopping the aeration;
- d. adding and mixing additional waste stream material;
- e. mixing and aerating until the ORP is positive and dissolved oxygen content is present;
- f. stopping the mixing and the aeration; and
- g. allowing settling to produce a decantable volume having a high content of facultative aerobes and nitrifiers,

the fraction of the drawn-off portion conducted to the treatment vessel being taken from the decantable volume.

30. The method of claim 29 further comprising the step of repeating steps (d) through (f) at least twice prior to the settling step.

31. The method of claim 29 wherein the undecanted drawn-off portion is conditioned for re-use by steps comprising:

- a. removing about 1/3 of the undecanted drawn-off portion;
- b. adding additional activated sludge to replace the removed undecanted drawn-off portion; and
- c. adding additional waste stream material to achieve a second target suspended solids concentration.

32. The method of claim 31 wherein the second target suspended solids concentration is not more than about 7,500 mg/l.

1 33. The method of claim 29 wherein the target suspended solids concentration ranges from  
2 about 2,500 mg/l to about 7,500 mg/l.  
3

1 34. The method of claim 1 wherein the controlling step comprises:

- 2 a. adding, to the drawn-off portion, a quantity of activated sludge to achieve a target  
3 suspended solids concentration;
- 4 b. mixing the drawn-off portion without aeration to achieve anaerobic conditions  
5 without substantial sulfide generation;
- 6 c. stopping the mixing for a period of time;
- 7 d. mixing;
- 8 e. mixing and aerating until the ORP is positive; and
- 9 f. allowing settling to produce a decantable volume having a high content of

---

10 facultative anaerobes and facultative aerobes,

11 the fraction of the drawn-off portion conducted to the treatment vessel being taken from the  
12 decantable volume.  
13

1 35. The method of claim 34 wherein the undecanted drawn-off portion is conditioned for re-  
2 use by the step of:

- 3 g. adding additional waste stream material to achieve a second target suspended  
4 solids concentration.  
5

1 36. The method of claim 35 further comprising the step of repeating steps (b) through (g).



1 37. The method of claim 35 wherein the undecanted drawn-off portion is prepared for re-use  
2 by removing about 1/3 of the undecanted drawn-off portion.  
3

1 38. The method of claim 35 wherein the second target suspended solids concentration is not  
2 more than about 10,000 mg/l.  
3

1 39. The method of claim 34 wherein the target suspended solids concentration ranges from  
2 about 3,000 mg/l to about 10,000 mg/l.  
3

1 40. The method of claim 1 wherein the controlling step comprises:

2 a. adding, to the drawn-off portion, a quantity of activated sludge to achieve a target  
3 suspended solids concentration;

4 b. mixing the drawn-off portion without aeration to achieve anaerobic conditions  
5 without substantial sulfide generation;

6 c. mixing and aerating until the ORP is positive;

7 d. stopping the aeration but continuing the mixing; and

8 e. allowing settling to produce a high-load decantable volume and a volume  
9 containing settled solids,

10 the fraction of the drawn-off portion conducted to the treatment vessel being taken from the  
11 decantable volume.  
12

1 41. The method of claim 40 wherein additional treatment is provided by steps further  
2 comprising:

- 3 f. adding additional activated sludge to produce a concentrated mixture; and
- 4 g. repeating steps (b) through (f) until the volume containing settled solids
- 5 corresponds to a target volume.

1 42. The method of claim 41 wherein the target volume is about 90 to 95% of the drawn-off  
2 portion.

3  
1 43. The method of claim 41 further comprising the steps of:

- 2 a. determining a solids content of the concentrated mixture;
- 3 b. disposing of the concentrated mixture as waste if the solids content exceeds a
- 4 predetermined threshold; and
- 5 c. if the solids content does not exceed the predetermined threshold, (i) adding an
- 6 additional portion of the waste stream material to the concentrated mixture, (ii)
- 7 mixing, (iii) allowing settling to produce a decantable volume, (iv) drawing off
- 8 the decantable volume, and (v) repeating steps (i) through (iv) until no further
- 9 increase in solids content is achieved.

10  
1 44. The method of claim 43 wherein the predetermined threshold high solids content is about  
2 90% of the drawn-off portion.

3  
1 45. The method of claim 40 wherein the target suspended solids concentration ranges from  
2 about 5,000 mg/l to about 7,500 mg/l.

3  
1 46. The method of claim 1 wherein the controlling step comprises:

- 2 a. adding, to the drawn-off portion, a quantity of activated sludge to achieve a target  
3 suspended solids concentration;  
4 b. mixing the drawn-off portion without aeration to achieve anaerobic conditions  
5 without substantial sulfide generation;  
6 c. mixing and aerating until the ORP is positive;  
7 d. stopping the aeration but continuing the mixing;  
8 e. allowing settling;  
9 h. aerating and mixing until a positive ORP is achieved; and  
10 i. allowing settling to produce a low-load decantable volume and a volume  
11 containing settled solids,  
12 the fraction of the drawn-off portion conducted to the treatment vessel being taken from the  
13 decantable volume.
- 

14  
1 47. The method of claim 46 wherein additional treatment is provided by steps further  
2 comprising:

- 3 j. adding additional activated sludge to produce a concentrated mixture; and  
4 k. repeating (b) through (j) until the volume containing settled solids corresponds to  
5 a target volume.  
6

1 48. The method of claim 47 wherein the target volume is about 90 to 95% of the drawn-off  
2 portion.  
3

1 49. The method of claim 47 further comprising the steps of:

- 2 a. determining a solids content of the concentrated mixture;
- 3 b. disposing of the concentrated mixture as waste if the solids content exceeds a
- 4 predetermined threshold; and
- 5 c. if the solids content does not exceed the predetermined threshold, (i) adding an
- 6 additional portion of the waste stream material to the concentrated mixture, (ii)
- 7 mixing, (iii) allowing settling to produce a decantable volume, (iv) drawing off the
- 8 decantable volume, and (v) repeating steps (i) through (iv) until no further increase in
- 9 solids content is achieved.
- 10

1 50. The method of claim 49 wherein the predetermined threshold high solids content is about

2 90% of the drawn-off portion.

3

---

1 51. The method of claim 46 wherein the target suspended solids concentration ranges from

2 about 5,000 mg/l to about 7,500 mg/l.

3

1 52. The method of claim 1 wherein the treatment vessel contains disposable solids,

2 introducing the returned fraction to the treatment vessel causing the disposable solids to increase

3 in concentration at the expense of biology.

4

1 53. The method of claim 1 wherein the treatment vessel contains disposable solids,

2 introducing the returned fraction to the treatment vessel causing the disposable solids to decrease

3 in nutrient content.

4

- 1 54. An apparatus for treating a waste stream comprising:
- 2 a. a first treatment vessel;
- 3 b. means for conducting at least a portion of the waste stream to the first treatment
- 4 vessel for treatment comprising contact with a first biology population having a
- 5 first-biology population profile;
- 6 c. means for drawing off a portion of the waste stream prior to introduction into the
- 7 first treatment vessel;
- 8 d. a second treatment vessel for receiving the drawn-off portion of the waste stream;
- 9 e. means for controlling the drawn-off portion of the waste stream so as to maintain,
- 10 in the second treatment vessel, a second biology population having a second-
- 11 biology population profile different from the first-biology population profile; and
- 12 f. means for conducting a fraction of the drawn-off portion from the second
- 
- 13 treatment vessel to the first treatment vessel following contact with the second
- 14 biology population, the returned fraction including a portion of the second biology
- 15 population.
- 16

- 1 55. The apparatus of claim 54 further comprising an overflow weir of variable height.